

Degradation of Deca-BDE

Recent scientific work
since interim CAP

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- Evaluated distribution of PBDEs (tetra to deca) in vicinity of US plastics facility¹
 - Deca found in effluent from waste water treatment plant, stream water and sediment.
 - Found also in one of two fish species
 - Many other PBDEs found in samples
 - Unable, however, to determine if congeners present due to deca degradation

¹La Guardia et al. Abstract from 'Third International Workshop on Brominated Flame Retardants', (2004)

- Evaluated of deca in sewage sludge by microbes under anaerobic conditions²
 - Deca mixed with sewage sludge & incubated for 238 d. at 37 °C
 - Deca conc. evaluated at various points during 238 day period
 - At least 5% of deca degraded to lower brominated products
 - Even more deca may have degraded to unknown products
- Also took one sample of inlet and outlet of anaerobic digester from same sewage plant³
 - Nona-BDE found to increase during digestion
 - Caution: only one sample taken and digestion only 28 days so results not substantiated.

²Gerecke et al. Abstract from 'Third International Workshop on Brominated Flame Retardants', (2004)
and Gerecke et al. Environ. Sci. Technol. (2005)

³Gerecke et al., Environ. Sci. Technol. (2005)

- Evaluated artificial UV deca degradation⁴
 - Degradation evaluated in organic solvents and water with and without humic acids
 - Deca found to degrade under all conditions
 - Degradation rate decreased with each debromination
 - Experiments in water with humic acids produced higher proportion of pentabromodibenzofurans
 - Experiments in water without humic acids very difficult to carry out

⁴Eriksson et al., Environ. Sci. Technol., (2004)

- Evaluated natural UV deca degradation⁵
 - Deca dissolved in hexane and subjected to sunlight in July and October
 - Deca found to degrade to lower congeners
 - BDE-47 (tetra) found within 28 hours or less
 - BDE-85, -99, and 100 (all penta) also found
 - Rate decreased with each successive debromination
 - Authors doing more work with deca dissolved in humic acids. Initial reports indicated same reaction pathways but rate much slower

⁵Bezares-Cruz et al., Environ. Sci. Technol., (2004)

- Evaluated deca degradation in house dust after 90 hours of natural UV degradation⁶
 - Deca dissolved in toluene, added to house dust, sealed in glass containers & subjected to Aug sunlight
 - Deca found to degrade to lower congeners
 - Degradation to nona-, octa- and hepta-BDE congeners
 - ~20% of original deca mass loss through possible volatilization and/or formation of unidentified products
 - Author doing more work with deca without organic solvents and more virgin dust.

⁶Stapleton, NIST (2005)

- Evaluated deca degradation using numerous reducing agents such as elemental iron, and iron and sodium sulfide⁷
 - PBDEs analyzed 9 times from 3 hrs to 40 d.
 - Samples with iron experienced 90% debromination generating mono- to hexa-BDE congeners. Mass balance accounted for ~45% of total. Large amounts of unidentified products found.
 - Samples with iron and sodium sulfide also lead to debromination of deca. Rate found to be much slower.
 - Sequential debromination indicated.

⁷Keum and Li, Environ. Sci. Technol., (2005)

- Limited results on deca degradation in the Environment:
 - Fish have limited capacity to metabolize deca⁸
 - Degradation correlation found between deca and lower congeners in marine environment but not in freshwater⁹
 - Deca degradation reason for difference in PBDE concentrations between composted and uncomposted biosolids¹⁰

⁸ Lebeuf et al., Abstract from 'Third International Workshop on Brominated Flame Retardants', (2004)

⁹ Voorspoels, et al., Abstract from 'Third International Workshop on Brominated Flame Retardants', (2004)

¹⁰ Kolic, et al., Abstract from 'Third International Workshop on Brominated Flame Retardants', (2004)

- Conclusions:

- Deca-BDE undergoes degradation. The most common path in laboratory studies is the debromination of deca-BDE to lower PBDE species, i.e. PBDEs with lower numbers of bromines. Other products have been found in some studies including brominated dioxins, phenols and dibenzofurans. These degradation products have been shown to have a negative impact upon human health and the environment.
- Debromination of deca-BDE occurs through light exposure (both UV radiation and direct sunlight) and biological activity. These pathways lead to a variety of degradation products.

- Conclusions (cont):
 - Debromination rates determined in laboratories studies. Further work is needed to determine the debromination rate under environmental conditions. Degradation will occur in both situations although at difference rates with degradation in the environment occurring more slowly. This has been shown with compounds with similar chemical structure.
 - Deca-BDE will continue to be a source of lower brominated diphenyl ethers and other degradation products for some time.